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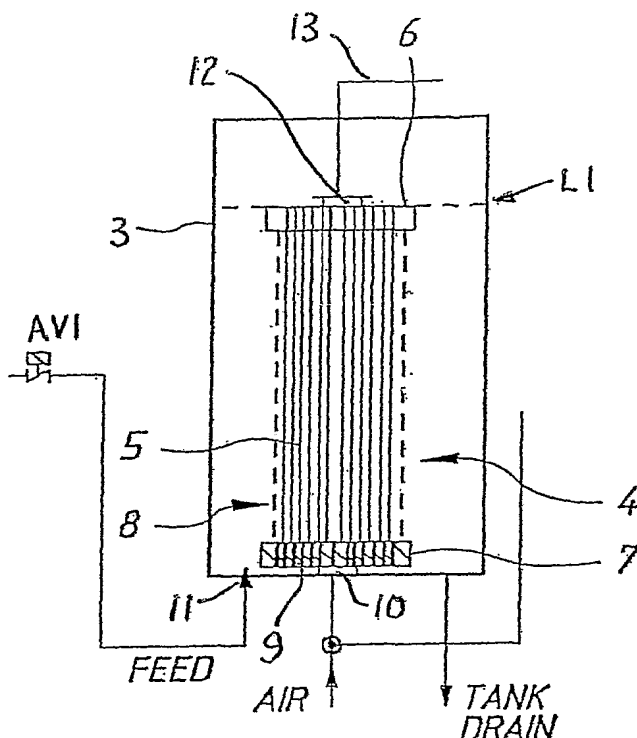
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[Continued on next page]

(54) Title: BACKWASH



**(57) Abstract:** A method of backwashing a membrane filtration module (4), said module (4) including one or more membranes (5) located in a feed-containing vessel (3), the membranes (5) having a permeable wall which is subjected to a filtration operation wherein feed containing contaminant matter is applied to one side of the membrane wall and filtrate is withdrawn from the other side of the membrane wall, the method including: removing liquid from the feed-containing vessel (3) until the level of liquid in the feed-containing vessel (3) falls to a first level (L2) below an upper level of the membranes; suspending the filtration operation; performing a liquid backwash of the membrane wall until liquid level within the feed-containing vessel (3) rises to a second predetermined level (L1) above said first level; aerating the membrane surface with gas bubbles to dislodge fouling materials therefrom; performing a sweep or drain down of the feed-containing vessel (3) to remove the liquid containing the dislodged contaminant matter; and recommencing the filtration operation.



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— *of inventorship (Rule 4.17(iv)) for US only*

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**TITLE: BACKWASH****TECHNICAL FIELD**

The present invention relates to membrane filtration systems and more  
5 particularly, the backwashing of such systems.

**BACKGROUND OF THE INVENTION**

Porous membrane filtration systems require regular backwashing of the  
membranes to maintain filtration efficiency and flux while reducing  
transmembrane pressure (TMP) which rises as the membrane pores become  
10 clogged with impurities. Such systems usually have a number of membranes in  
the form of bundles or arrays of membranes located in a feed tank. Feed is thus  
applied to the surfaces of the membranes and filtrate withdrawn from the  
membrane lumens. Typically, during the backwash cycle the impurities are  
forced out of the membrane pores by pressurised gas, liquid or both into the  
15 feed tank or cell. The liquid containing impurities and deposits from the  
membranes is then drained or flushed from the tank.

The waste liquid displaced from the tank needs to be disposed of or  
reprocessed, usually in an environmentally safe manner, so any reduction in the  
volume of such waste liquid is seen as advantageous in terms of environmental  
20 impact and cost.

The draining or flushing of the tank, particularly when large arrays of  
membranes are used also requires time which results in down time of the  
filtration cycle. In order to reduce this down time large pumping systems are  
required to quickly drain and refill the tank. Where tanks or cells are arranged in  
25 banks and feed is used to refill the tank, a lowering in levels in other cells may

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be produced during the refill process. This again impinges on operating efficiency of the filtration system.

Reduction in backwash volume also reduces the volume of chemical cleaning agents required in some systems. This has the two-fold advantage of  
5 reducing cost in terms of chemical requirements while also reducing waste disposal problems.

Many filtration systems also employ a gas bubble aeration method to assist in scouring unwanted deposits from the surfaces of the porous membranes during the cleaning stage. In order for such aeration to be effective the  
10 membranes must be fully immersed in liquid.

Typically the cleaning process in such systems includes ceasing flow of feed liquid to the vessel in which the membranes are located, continuing the filtration process until the level of liquid in the tank reaches the top of the membranes, aerating the membranes with gas bubbles to scour impurities from  
15 the outer membrane surfaces for a period of time, then liquid backwashing the membrane pores. The tank is then drained or flushed to remove the waste liquid containing the impurities dislodged during the aeration and backwashing processes.

It will be appreciated that it is necessary to keep the membranes  
20 submerged so as to make the aeration step effective. Adding the liquid backwash at the end of the aeration step results in the liquid level in the tank rising above the membranes. This is "wasted volume" in terms of the requirement of keeping the membranes submerged.

## SUMMARY OF THE INVENTION

The present invention seeks to overcome or at least ameliorate this and other disadvantages of the prior art.

According to one aspect, the present invention provides a method of  
5 backwashing a membrane filtration module, said module including one or more  
membranes located in a feed-containing vessel, the membranes having a  
permeable wall which is subjected to a filtration operation wherein feed  
containing contaminant matter is applied to one side of the membrane wall and  
filtrate is withdrawn from the other side of the membrane wall, the method  
10 including:

- a) removing liquid from the feed-containing vessel until the level of  
liquid in the feed-containing vessel falls to a first level below an  
upper level of the membranes;
- b) suspending the filtration operation;
- 15 c) performing a liquid backwash of the membrane wall until liquid  
level within the feed-containing vessel rises to a second  
predetermined level above said first level;
- d) aerating the membrane surface with gas bubbles to dislodge  
fouling materials therefrom;
- 20 e) performing a sweep or drain down of the feed-containing vessel to  
remove the liquid containing the dislodged contaminant matter;  
and
- f) recommencing the filtration operation.

Preferably, the second predetermined level is selected such that the liquid  
25 level rises at least to the upper level of the membranes during the aeration step.

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Preferably, the flow of feed into the feed-containing vessel is suspended prior to removal step a). For preference, the removal of liquid is achieved fully or partially by the filtration process. Preferably, in a pressurized filtration system, a pressurized gas is employed during the filtration process to push the liquid from  
5 the feed side through the permeable membrane wall during the removal step a). The aeration step may commence prior to removal of liquid step and continue until the sweep or drain down step e).

This process has the advantage of reducing the backwash volume. Also, rather than filtering down to the required liquid level, it is possible to drain or  
10 pump away liquid in the feed-containing tank to achieve the same result. This has the advantage of not increasing the flux of the membrane during the filter down step, and can be done quickly to reduce filtration down time. The drained feed may be returned to the inlet of the filtration plant so as not to be wasted, or transferred to other tanks operating in parallel.

15 In an alternate method, the filtration step may be done at varying filtrate flows; the flow being adjusted to maintain a constant transmembrane pressure (TMP) as the liquid level drops down the membranes.

The TMP may be monitored during the removal of liquid step and used to determine when the liquid level has dropped below the top of the membranes, or  
20 how far below the upper level of the membranes the liquid level has dropped. This is possible because as more of the membrane is exposed the filtration area is less and the TMP will increase. TMP will also increase due to the fact that more of the filtrate flow travels further along the lumen so increasing the lumen pressure drop (assuming the flow is kept constant and filtrate is being withdrawn  
25 from the upper end of the membrane lumen). Accordingly, the change in TMP

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may be used to monitor the liquid level in the feed tank before commencing the liquid backwash step. This may also be used to adjust the filtrate flow and maintain a constant TMP so avoiding significant changes in the flux on the remaining filtrate area. Alternatively, such a method can be used to control to  
5 the TMP to any desired predetermined level, for example, it may desirable to lower the liquid level in the feed-containing tank, keeping the TMP at the maximum allowable TMP, say 85 kPa.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

A preferred embodiment of the invention will now be described, by way of  
10 example only, with reference to the accompanying drawings in which:

Figures 1a to 1e show schematic views of the membrane module at various stages of the backwash process according to an embodiment of the invention.

### **DESCRIPTION OF THE PREFERRED EMBODIMENT**

15 Referring to the Figures 1a to 1e, an illustrative embodiment of the invention is described. The filtration module 4 is mounted within a housing vessel 3 which contains the feed to be filtered. The filtration module 8 contains a bundle or bundles of hollow fibre membranes 5 extending between upper and  
20 lower headers 6 and 7, respectively. The lower header 7 is provided with a number of openings 9 communicating with the interior of the fibre bundle and an inlet port 10. Feed is supplied through port 11 under the control of valve AV1.

Permeate/filtrate is withdrawn through chamber 12 and line 13. A liquid backwash may also be applied through line 13.

25 Figure 1a shows the module in normal filtration operation with the liquid level in the vessel 3 at L1 covering the upper header 6. When the backwash

stage is to be commenced, in this embodiment, the flow of feed is stopped by shutting valve AV1. Filtrate continues to be withdrawn through the fibre lumens and chamber 12 and line 13. The level of liquid in the vessel 3 falls, as shown in Figure 1b, to level L2.

5        Once level L2 is reached, a liquid backwash is commenced by flowing liquid back through the fibre lumens and walls via line 13. This results in the liquid level again rising in the vessel to L1 as shown in Figure 1c. An aeration step is then commenced by feeding gas through port 10 and openings 9 as shown in Figure 1d. In another embodiment, the liquid level resulting from the  
10   liquid backwash may be just below level L1 such that level L1 is reached during the aeration step with the liquid level rising further as a result of bubbles present in the liquid. A similar result may be achieved by commencing the aeration step during the liquid backwash.

      Once the aeration step is completed the vessel is swept or drained as  
15   shown in Figure 1e to remove dislodged waste materials accumulated in the vessel liquid. Following this step feed is reintroduced to the vessel by opening valve AV1 and filtration recommenced.

      Although the embodiment relates to vertically orientated membranes, it will be appreciated that the invention is not limited to such an orientation and the  
20   membranes may be orientated in any desired position or configuration.

      It will be appreciated that the invention may be applied to both pressurized and non-pressurized systems where the feed-containing vessel is open to atmosphere.



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It will be appreciated that further embodiments and exemplifications of the invention are possible with departing from the spirit or scope of the invention described.

## CLAIMS:

1. A method of backwashing a membrane filtration module, said module including one or more membranes located in a feed-containing vessel, the membranes having a permeable wall which is subjected to a filtration operation  
5 wherein feed containing contaminant matter is applied to one side of the membrane wall and filtrate is withdrawn from the other side of the membrane wall, the method including:
  - a) removing liquid from the feed-containing vessel until the level of liquid in the feed-containing vessel falls to a first level below an  
10 upper level of the membranes;
  - b) suspending the filtration operation;
  - c) performing a liquid backwash of the membrane wall until liquid level within the feed-containing vessel rises to a second predetermined level above said first level;
  - 15 d) aerating the membrane surface with gas bubbles to dislodge fouling materials therefrom;
  - e) performing a sweep or drain down of the feed-containing vessel to remove the liquid containing the dislodged contaminant matter; and
  - 20 f) recommencing the filtration operation.
2. A method according to claim 1 including selecting the second predetermined level such that the liquid level rises at least to the upper level of the membranes during the aeration step.
3. A method according to claim 1 or 2, wherein the flow of feed into the feed-  
25 containing vessel is suspended prior to removal step a).

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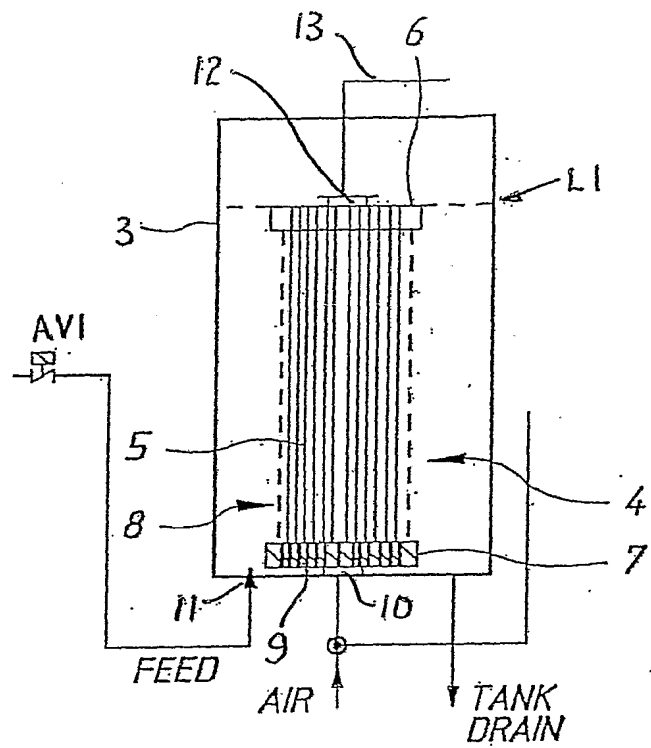
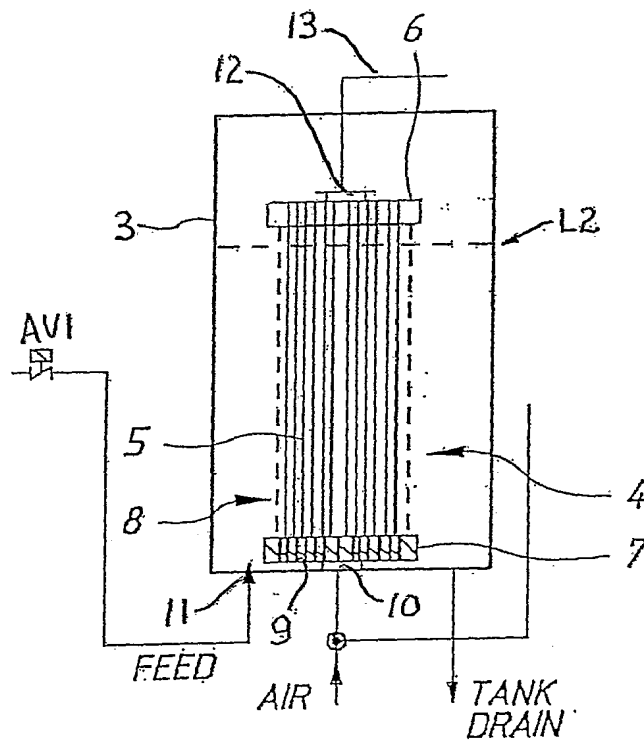
4. A method according to any one of the preceding claims wherein the aeration step is commenced prior to removal of liquid step and continues until the sweep or drain down step e).
5. A method according to any one of the preceding claims wherein the  
5 removal of liquid is achieved fully or partially by the filtration process.
6. A method according to claim 5 including applying a pressurized gas to the liquid on the said one side of the membrane wall to push the liquid through the membrane wall during the filtration process.
7. A method according to any one of claims 1 to 4 wherein the removal of  
10 liquid is achieved by drain down of liquid in the feed-containing tank.
8. A method according to any one of claims 1 to 4 wherein the removal of liquid is achieved by pumping liquid from the feed-containing tank.
9. A method according to any one of the preceding claims including the step of returning the removed liquid to the feed-containing vessel when filtration is  
15 recommenced.
10. A method according to any one of the preceding claims including the step of returning the removed liquid to the feed-containing vessel of a further filtration system.
11. A method according to anyone of the preceding claims including the step of  
20 varying filtrate flow from membranes to maintain a substantially constant transmembrane pressure (TMP) across said membranes as the liquid level is reduced within the feed-containing vessel.
12. A method according to claim 11 wherein the transmembrane pressure is maintained at or below a predetermined value.

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13. A method according to any one of the preceding claims including the step of monitoring the transmembrane pressure across said membranes to determine the level of liquid in said feed-containing vessel.

14. A method according to claim 13 wherein said monitoring step is performed  
5 during the removal step a).

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Fig. 1aFig. 1b

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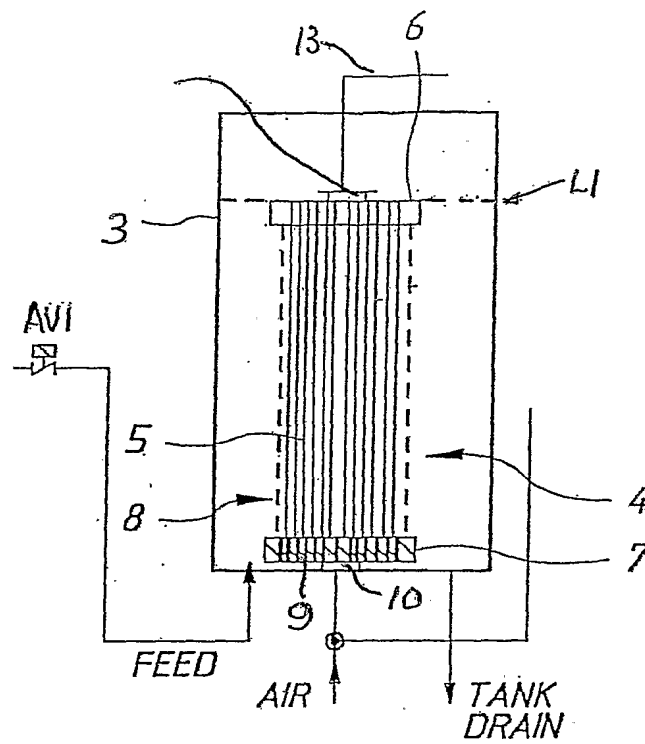
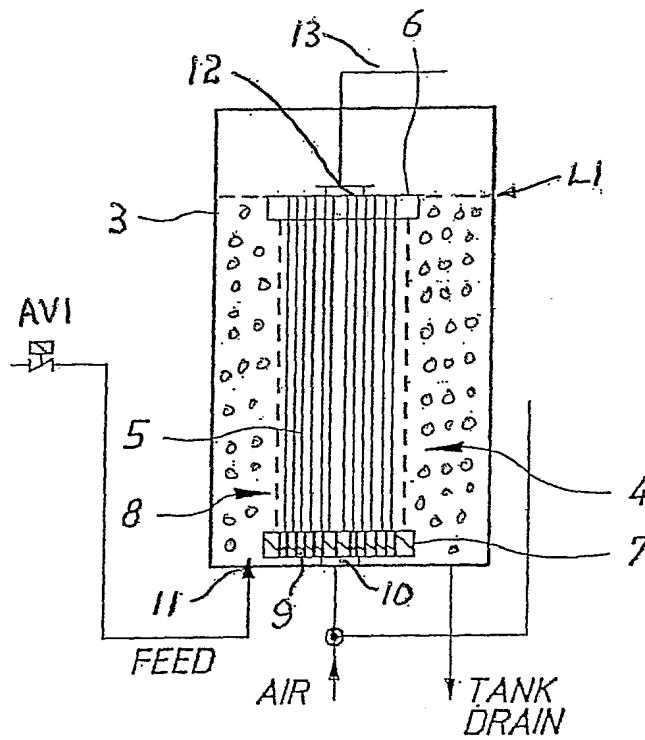


Fig. 1c

Fig. 1d

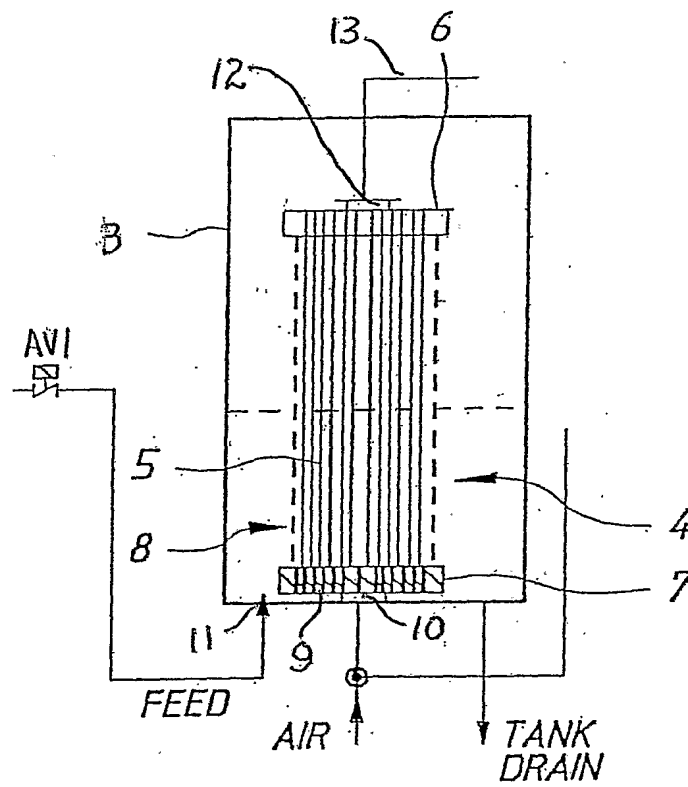


Fig. 1e

# INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/AU2004/001157**

## A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: **B01D 65/02**

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

**B01D 65/02**

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**DWPI + KW((AERAT+ or BUBBL+) and (BACKWASH+ or BACKFLUSH+))**

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO,A,2003013706 (US FILTER WASTEWATER GROUP, INC.) 20 February 2003 See whole document	1,3-4
A	WO,A,199302779 (MEMTEC LIMITED) 18 February 1993 See whole document	
A	WO,A,199607470 (MEMTEC LIMITED) 14 March 1996 See whole document	
A	WO,A,199828066 (MEMTEC AMERICA CORPORATION) 2 July 1998 See whole document	

☐ Further documents are listed in the continuation of Box C

☒ See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
"P" document published prior to the international filing date but later than the priority date claimed	

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**5 OCT 2004**

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/AU2004/001157

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report				Patent Family Member			
WO	03013706	CA	2456479	EP	1420874		
WO	9302779	AU	24220/92	AU	62042/96	AU	94068/98
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		US	2004084369	US	2004145076	US	2004168979
		US	2004178154				
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.							
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